Zero-Point Radiation and the Big Bang

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This paper develops a cosmological hypothesis based on the following propositions:

1. Zero-point radiation derives from quantic fluctuations in space, and the wavelength of its photons with the greatest energy is inversely proportional to the curvature of space.
2. The Universe began as the breaking in of photons of extremely high energy contained in the 3-dimensional surface: $w^2+x^2+y^2+z^2=R_i^2$, whose radius has continued to expand at the speed of light since its origin at $t=0$.
3. The wavelength of the photons is quantized and the quantum of wavelength is invariable.

These propositions imply that the value of the total energy of the zero-point radiation in the Universe remains constant and the condition $w^2+x^2+y^2+z^2=(R_i+ct)^2=R_u^2$ determines that every point in our space is subject to a tension whose intensity i is proportional to the curvature $1/R_u$. Any increase of R_u implies a decrease in i and consequently an energy flow which translates into an expansive force. Therefore, the Universe will expand indefinitely: no Big Crunch is possible. If the initial radius of the Universe R_i has been smaller than the Schwarzschild radius, R_s, which corresponds to the total mass of the Universe, M_u, the generation of matter would have lasted for thousands of millions of years. Generation of matter over short periods would have required values for R_i of thousands of millions of light years.

I. INTRODUCTION

We must distinguish between the Universe, the material Universe and the visible Universe. The radius of the Universe, R_u, measures R_i+ct, where t is the time elapsed since $t=0$, but we are unable to measure it. The material Universe consists of elementary particles and cosmic objects. Obviously, its radius, R_m, is shorter than R_u.

The expansion of the Universe determines that everything which is very far away from us, may recede at velocities equal or greater than c, which implies the existence of a horizon of visibility. We can only observe extremely luminous cosmic objects which recede at a speed near that of light. The value of the angle φ which defines the visible Universe is such than 1 radian $<\varphi$ radians $<\pi$ radians; $1/\varphi=v_m/c$, where v_m is the present rate of increase in the length of the radius of the material Universe. Both φ and v_m are functions of the relation, R_0/R_s, between the radius of the material Universe at the end of the generation of matter, R_0, and the Schwarzschild radius, R_s.

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In 1916, Nernst suggested that the quantic fluctuations of space must cause an electromagnetic radiation which would therefore be inherent to space and, consequently, have a spectrum which is relativistically invariant.

In 1958, Sparnaay found this radiation when he was measuring the Casimir effect at temperatures close to absolute zero. He detected some radiation which was independent of temperature, with a spectrum such that the intensities of its flows are inversely proportional to the cubes of their wavelengths, which is a necessary condition for the radiation to be relativistically invariant [1], [2], [3]. In 1997, S. K. Lamoureux carried out new measurements of the intensity of the energy flow of zero-point radiation, using a very different method, and reached the same measurements as Sparnaay's [12].

A function of spectral distribution which is inversely proportional to the cubes of the wavelengths, implies a distribution of energies which is proportional to the 4^{th} power of the wavelengths, because the energies of the photons are inversely proportional to the wavelengths. In 1969, Timothy H. Boyer, [7], [8], showed that the spectral density function of zero-point radiation is:

$$f_\varphi(\lambda)=\frac{1}{2\pi^2}\frac{1}{(\lambda_*)^3}, \tag{1}$$

where λ_* is the number giving the measurement of the wavelength λ.

This function produces the next, for the corresponding energies

$$E_\varphi(\lambda)=\frac{1}{2\pi^2}\frac{hc}{\lambda}\frac{1}{(\lambda_*)^3}. \tag{2}$$

For $\lambda\to 0$, $E_\varphi(\lambda)\to\infty$. There must be, therefore, a threshold for λ, which will be hereafter designated by the symbol q_λ.

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To simplify the following arguments, it is convenient to use the (e,m_e,c) system of units in which the basic units are the quantum of electric charge, e, the mass of the electron, m_e, and the speed of light, c. In this system the units of length and time are, respectively, $l_e=e^2/(m_ec^2)$ and $t_e=e^2/(m_ec^3)$. The unit of length is equal to the classic radius of the electron.

Zero-point radiation proceeds equally from all directions of space, and its interactions with electrons could, therefore, play the role of the "Poincarè tensions", preventing the electron from shattering as a result of the repulsion of its charge against itself. For his to be the case, there must operate the equation:

$$x^3 = \frac{4\pi^3}{3\alpha}(k_\lambda)^4(r_x)^4[B]_m; \tag{3}$$

equation 17 in [4], where:

$x =$ measurement of the wavelength of the photons with the greatest energy in zero-point radiation, expressed in q_λ (quanta of wavelength).

$k_\lambda =$ measurement of l_e, expressed in q_λ.

$r_x =$ measurement of the radius of the electron, expressed in l_e.

$$[B]_m = \frac{7}{48}B - \frac{11}{50}B^2 + \cdots + T_m B^m,$$

where:

$$B = \frac{2\pi}{\alpha}\left(\frac{k_\lambda}{x}\right)$$

$$T_m = (-1)^{m-1}$$

$$\left[\frac{1}{m+1} + \frac{2}{m+2} - \frac{3}{m+3} - 1 - \frac{m(m-1)}{6}\right]\frac{1}{m+3}$$

The hypothesis that zero-point radiation is also the effective cause of gravitational attraction between two electrons leads to the equation:

$$x^3 = \frac{2\pi^2}{3\alpha}\frac{(k_x)^2(r_x)^2[B]_m}{G_e}; \tag{4}$$

equation 20 in [4].

In [4] it was also deduced that:

$$r_x = 1 l_e$$

$$k_\lambda = \left[\frac{1}{2\pi G_e}\right]^{1/2}; \qquad G_e = \frac{1}{2\pi(k_\lambda)^2} \tag{5}$$

$q_\lambda = (2\pi\alpha)^{1/2}L_P$, where L_P is the Planck length.

$$\left.\begin{aligned} k_x &= 8.143375 \times 10^{20} \\ x &= 5.257601 \times 10^{27} \end{aligned}\right\} \tag{6}$$

II. BASIC PRINCIPLES OF THE PROPOSED HYPOTHESIS

The proposed hypothesis rests on the following basic principles:

1. The "Big Bang" consisted of the appearance, at $t = 0$, of a primal space configured as the 3-dimensional surface $w^2 + x^2 + y^2 + z^2 = (R_i)^2$ of radius R_i light-years, whose zero-point radiation was characterized by the fact that its photons of greater energy possessed a wavelength of $x_i q_\lambda = k_u(R_i/R_u)q_\lambda$. Within the primal space there would have existed photons unconnected to that zero-point radiation.
2. After a lapse of t years those photons which had not been transformed into elementary particles would, after travelling in all directions, have covered a distance of $R_t = (R_i + t)$ light years, and the wavelength of the photons of greatest energy in zero-point radiation would have increased to $x_t q_\lambda = k_u(R_t/R_u)q_\lambda$, so that the wavelengths of these photons would always be directly proportional to the radius of the Universe and, therefore, inversely proportional to its curvature. $k_u = \dfrac{R_u}{x} = 7.264351 \times 10^{33}$.
3. The quantum of wavelength, q_λ, is intrinsically invariant.

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The analysis of the proposed hypothesis requires us to consider how the numbers x, k_λ and G_e, as also the mass of the electron, have evolved, according to its principles, from $t = 0$ until the present, since any impossibility or absurdity in that evolution would compel us to reject the hypothesis. We do not need to extend our consideration to the gravitational constant, $G = G_e l_e c^2 m_e^{-1}$, because the terms of the hypothesis imply the invariance of this constant. In fact:

$$G_e = 1/2\pi(k_\lambda)^2; \qquad l_e = k_\lambda q_\lambda,$$

and the product, $*_e = m_e l_e$, of the mass of the electron and its radius is a fundamental quantic threshold, no matter what values of m_x and r_x are possessed by the mass and the radius of the electron, the product $(m_x m_e)(r_x l_e)$ will always be equal to $m_e l_e = 1*_e$. Keeping this in mind, we can write for the gravitational constant,

$$G = \frac{1}{2\pi(k_\lambda)^2}\frac{l_e^2 c^2}{m_e l_e} = \frac{(k_\lambda)^2(q_\lambda)^2c^2}{2\pi(k_\lambda)^2 *_e} = \frac{(q_\lambda)^2c^2}{2\pi *_e},$$

which is invariant, because q_λ, c and $*_e$ are invariant. In fact the variations of G_e over time are those which are required to preserve the invariance of the gravitational constant against the variations of l_e, i.e. those of k_λ.

III. EVOLUTION OF SOME VARIABLES AND CHARACTERISTICS OF THE UNIVERSE SINCE T=0

In 1929 Hubble discovered that the Universe is expanding and, according to the "Big Bang" theory, everything started with the breaking in of an enormous amount of energy contained within a relatively small space, whose volume has been increasing since that break-in at $t = 0$. In the first basic principle of this hypothesis we have suggested that the initial space was configured as the 3-dimensional spherical surface $w^2 + x^2 + y^2 + z^2 = (R_i)^2$, full of photons of very high energy, which then dispersed in all directions.

Fig. 1 shows the upper half of the 2-dimensional spherical surface $x^2 + y^2 + z^2 = R^2$, in which we also see a smaller circle of radius $r = R \sin\varphi$. The intersection of this surface with the plane $z = 0$ is the circumference: $x^2 + y^2 = R^2$ situated on that plane. On the other hand, this 2-dimensional spherical surface can be viewed as having been generated by the differential surface element $2\pi rRd\varphi = 2\pi R^2 \sin\varphi d\varphi$, by being integrated between $\varphi = 0$ and $\varphi = \pi/2$. In effect:

$$2\pi R^2 \int_0^{\pi/2} \sin\varphi d\varphi = 2\pi R^2,$$

which is the area of the said upper half of the spherical surface of radius R.

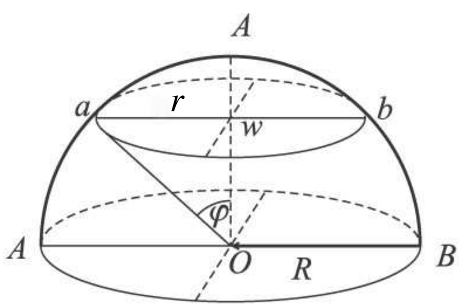

FIG. 1: Fig. 1

Using the same method, we may consider that the 2-dimensional spherical surface $x^2 + y^2 + z^2 = R^2$ is the intersection of the 3-dimensional spherical surface $w^2 + x^2 + y^2 + z^2 = R^2$ with the plane surface (also 3-dimensional) $w = 0$, and imagine that 3-dimensional spherical surface as having been generated by the differential element of volume $dV = 4\pi(R\sin\varphi)^2 Rd\varphi$, whence:

$$\frac{V}{2} = 4\pi R^3 \int_0^{\pi/2} \sin^2\varphi d\varphi = 4\pi R^3 \frac{\pi}{4} = \pi^2 R^3,$$

i.e.,

$$V = 2\pi^2 R^3.$$

After this digression it is easier to imagine what a 3-dimensional surface is. Because of the manner of its generation, it must possess volume, not area, and because its points must fulfill the condition $w^2 + x^2 + y^2 + z^2 = R^2$, it must act as a frontier between the internal points in the 4-dimensional sphere delimited by it, in which $w^2 + x^2 + y^2 + z^2 < R^2$, and those points external to it in which $w^2 + x^2 + y^2 + z^2 > R^2$. The link between the 4 coordinates w, x, y and z is analogous to that which exists between the 3 coordinates of the 2-dimensional spherical surface; this is nothing more than a simple relation with the curvature of the surface, which in all the spherical surfaces is the same at all its points, because it is at all points equal to $1/R$. It follows, from this, that the said link does not require the existence of differences inherent to positions in space, and this is a necessary condition for the truth of the first postulate of the Special Theory of Relativity. There are no such differences either in the inner points nor in those external to its boundaries delimited by $x^2+y^2+z^2 = R^2$ or by $w^2+x^2+y^2+z^2 = R^2$, since both are unaffected by geometric conditions.

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Zero-point radiation is inherent to space, and can therefore be considered to be an intrinsic component of its essential nature, no matter what this may be. According to the hypothesis formulated above, zero-point radiation has the following characteristics:

- Its photons of greatest energy have a wavelength of $x_t q_\lambda = k_u \left(\frac{R_i + ct}{R_0}\right) q_\lambda$.
- It is relativistically invariant. This implies that during every time lapse $x^3 t$ one photon of wavelength x will strike on a given area l^2. In other words, the abundance of its photons is inversely proportional to the cubes of their wavelengths.
- The wavelengths of its photons will increase proportionally to the increase in the radius of the Universe $R_t = (R_i + ct)$ l.y.

The variation in the wavelengths of the photons of zero-point radiation is similar to the variation in the lengths of the tracings which could be drawn on a balloon made of a perfectly elastic membrane. The first tracings, at $t = 0$, when the balloon has a radius or R_{B0}, would increase in proportion to the radius of the balloon R_{Bt}, as it inflates. The similarity is closer if we imagine not tracings but perfectly elastic fibres which would form a physical part of the balloon. These fibres would stretch, but would still constitute a fixed network, while zero-point radiation is a network which is spreading at the speed of light. However, the analogy holds, so far it concerns the increase in lengths which is inherent to the nature of spherical surfaces displayed by both the balloon in our example, and space, according to the proposed hypothesis. The suggestion that space is configured as a 3-dimensional spheric surface is by no means a trivial one.

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The measurements made by Sparnaay and Lamoreux allow us to infer that the present wavelength of the photons with the greatest energy in zero-point radiation is $x = 5.257601 \to 10^{27} q_\lambda$, which implies an energy flow per $(q_\lambda)^2$ during every q_τ, which is given by:

$$\frac{E_{0x}}{(q_\lambda)^2 q_\tau} = \frac{1}{(q_\lambda)^2 q_\tau}\frac{hc}{q_\lambda}\left(\sum_x^\infty n^{-4}\right)$$

$$= \frac{1}{(q_\lambda)^2 q_\tau}\frac{2\pi}{\alpha}k_\lambda\left(\sum_x^\infty n^{-4}\right)m_e c^2.$$

Since $q_\tau = q_\lambda/c$ is the minimum lapse of time which can apply to electromagnetic waves, and since these waves move at the speed of light, the amount of energy in the zero-point radiation per $(q_\lambda)^3$ is given by:

$$\frac{E_{0x}}{(q_\lambda)^3} = \frac{1}{(q_\lambda)^3}\frac{hc}{(q_\lambda)}\left(\sum_x^\infty n^{-4}\right)$$

$$= \frac{1}{(q_\lambda)^3}\frac{2\pi}{\alpha}k_\lambda\left(\sum_x^\infty n^{-4}\right)m_e c^2,$$

and since

$$\sum_x^\infty n^{-4} = \frac{1}{3x^2} + \frac{1}{2x^4} + \frac{1}{3x^5} - \frac{1}{6x^7} + \cdots,$$

we can write as a first approximation:

$$\frac{E_{0x}}{(q_\lambda)^3} = \frac{2\pi}{\alpha}\frac{k_\lambda}{3x^3}m_e c^2;$$

whence

$$\frac{E_{0x}}{(l_e)^3} = \frac{2\pi}{3\alpha}\frac{(k_\lambda)^4}{x^3}m_e c^2,$$

with a relative error less than $\frac{1}{2x^4} : \frac{1}{3x^3} = \frac{3}{2x}$, which for the present value of x is $\varepsilon < 2.853 \times 10^{-28}$.

If we introduce the previously given value of x, and $k_\lambda = 8.143375 \times 10^{20}$ and the transformation coefficient of $(l_e)^3$ to (l.y.)^3, $k_{ely} = 3.783997 \times 10^{91}$ we obtain $E_{0x} = 3.286237 \times 10^{94} m_e c^2$ per (light year)^3.

According to our hypothesis the radius of the Universe expressed in light years is very approximately equal to its age expressed in years, because $R_u = R_i + ct$ and R_i/R_u must be insignificant.

The age of the Universe is estimated through the Hubble constant, H_u, whose value has been estimated as not being greater than $\frac{90\text{ km/s}}{3.26\times 10^6\text{l.y.}}$ and not less than $\frac{60\text{ km/s}}{3.26\times 10^6\text{l.y.}}$. Its median value, $\frac{70\text{ km/s}}{3.26\times 10^6\text{l.y.}}$ corresponds to an age equal to 1.39×10^{10} years and to the radius $R_u = 1.39 \times 10^{10}$ l.y. For this value, the total energy of the zero-point radiation in the Universe is given by:

$$E_U^* = 2\pi^2(1.39 \times 10^{10})^3 3.286237 \times 10^{94} m_e c^2$$

$$= 1.742 \times 10^{126} m_e c^2.$$

This value is immensely greater than the energy equivalent of the mass of the Universe as estimated in [5], pg. 2, which is $1.55 \times 10^{79} m_e c^2$.

It is obvious that, if the radius of the Universe at $t = 0$ was $R_i \ll R_u$, and if the wavelength of the photons with greatest energy in zero-point radiation has not varied, the expansion of the Universe would have required the increasing inflow of an enormous flow of photons, in order to keep unchanged the amount of energy in the form of zero-point radiation per unit of volume, in a volume $2\pi^2(R_i + ct)^3$ which grows in proportion to the cube of the radius of the Universe, $R_t = R_i + ct$.

The density of the energy of zero-point radiation is given by:

$$\frac{E_{0x}}{(q_\lambda)^3} = \frac{hc}{(q_\lambda)^4}\sum_x^\infty n^{-4}$$

$$= \frac{hc}{(q_\lambda)^4}\left(\frac{1}{3x^3} + \frac{1}{2x^4} + \frac{1}{3x^5} - \frac{1}{6x^7} + \cdots\right). \quad (7)$$

The volume of the Universe is given by:

$$V_{ut} = 2\pi^2(R_t)^3(q_\lambda)^3 = 2\pi^2(R_i + ct)^3(q_\lambda)^3,$$

where R_i is the radius of the Universe at $t = 0$ and t is the time, expressed in q_τ, elapsed since $t = 0$.

The total energy of the Universe after the lapse of tq_τ since $t = 0$ is, therefore:

$$E_U^* = 2\pi^2(R_i + ct)^3(q_\lambda)^3\frac{hc}{(q_\lambda)^4}$$

$$\times\left\{\frac{1}{3x^3} + \frac{1}{2x^4} + \frac{1}{3x^5} - \frac{1}{2x^7} + \cdots\right\} =$$

$$= \frac{2\pi^2 hc}{q_\lambda}\left\{\frac{(R_i + ct)^3}{3x^3} + \right.$$

$$\left.\frac{(R_i + ct)^3}{2x^4} + \frac{(R_i + ct)^2}{3x^3} - \frac{(R_i + ct)^3}{6x^7} + \cdots\right\}.$$

If the wavelength of the photon of greatest energy in zero-point radiation is proportional to the radius of the Universe, its value when that radius measured $R_i q_\lambda$ must

have been $(R_i/k)q_\lambda$, and when the radius measures $(R_i + ct)q_\lambda$ the wavelength must be $(R_i + ct)q_\lambda/k_u$, where k_u is a natural number, whence:

$$E_U^* = \frac{2\pi^2 hc}{q_\lambda} k_u^3 \left\{ \frac{1}{3} + \frac{1}{2x} + \frac{1}{3x^2} - \frac{1}{6x^4} + \cdots \right\}. \quad (8)$$

The terms within the bracket after the first term are insignificant in comparison to it when x is very large, and form a remainder what could represent the energy needed to maintain the curvature of the Universe. We should remember here that the condition for the relativistic invariance of the spectrum of zero-point radiation is precisely that which causes its total energy in the Universe to remain substantially constant, whilst the radius of the Universe increases indefinitely. Moreover (8) shows that the energy needed to maintain the curvature of the Universe is inversely proportional to the radius of the Universe, i.e. proportional to the said curvature.

Table 1 gives a list of values for x, k_λ, $\Delta_s k_\lambda$, R, R_s and R/R_s as they vary with values of $z = k_\lambda/x$.

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The values of x have been obtained through the equation:

$$x = \frac{3\alpha}{4\pi^3 z^4 [B]_m}, \quad (9)$$

which results from dividing the two terms of equation (3) by x^4, taking $r_x = 1$ and $\frac{k_\lambda}{x} = z$. The values of k_λ derive from $k_\lambda = zx$, while those of $\Delta_s k_\lambda$, which is the increase of k_λ per second have been obtained from those of $\Delta_s x$ through the equation

$$\Delta_s k_\lambda = \frac{3}{4} \left(\frac{\alpha}{4\pi^3 [B]_m} \right)^{1/4} \frac{\Delta_s x}{x^{1/4}}.$$

The values of $\Delta_s x$, increase of x per second, are obtained by dividing the present value of x, $x = 5.257601 \times 10^{27} q_\lambda$, by the present age of the Universe expressed in seconds; $t = 4.386413 \times 19^{17}$ s.; this produces a constant value of $1.198610 \times 10^{10} q_\lambda/s$. This value seems at first sight very large, but is in reality very small, being equivalent to 4.147682×10^{-24} cm/s, and to $2.28 \times 10^{-18} x$. If we go back in time 65 millions of years, i.e. to the end of the era of the dinosaurs, the value of x will have diminished some $2.45 \times 10^{26} q_\lambda$ which are only a 4.67% of its present value. Finally, the values for R_s have been found through $R_s = \frac{M_u G}{c^2}$, which in the (e, m_e, c) system is written as:

$$R_s = M_0 m_e G_e (l_e c^2 m_e^{-1}) = \frac{M_0}{2\pi (k_\lambda)^2} l_e = \frac{M_0}{2\pi (k_\lambda)} q_\lambda$$

We deduced above that the value of the gravitational constant, G, remains invariant when x varies, and that the variation in its numerical coefficient in the (e, m_e, c) system is precisely the variation required for G to remain invariant against variation in the length of the radius of the electron $r_e = l_e = k_\lambda q_\lambda$, and consequently against variation in the mass of the electron, since the product of radius and mass, $m_x l_x = e^2/c^2$, must remain constant.

Since the value of R_0 is the measurement of the radius of the Universe at the moment when the last elementary particle was generated, values of R_0 where $R_0/R_s < 1$ would cause its collapse and transformation into a black hole. We can see from Table 1 that the value of x which corresponds to $R_0/R_s = 1.0003$ is 2.7792×10^{25}, for which the value of $\frac{1}{2x} + \frac{1}{3x^2} - \frac{1}{6x^4}$ is less than 1.8×10^{-26}, and the difference between the total energy of zero-point radiation in the Universe as the product of the Universe's volume and the density of the energy of that radiation, and the product which results from disregarding the said remainder is, relatively, insignificant.

Table 1 provides a basis of reference for the estimate that the age of the Universe is 1.39×10^{10} years and that the mass of the Universe is $1.55 \times 10^{79} m_e$, [4] pp. 2-3. The first of these estimates derives from taking the value of the Hubble constant to be 70 km/s per megaparsec, so that the time needed to reach the "horizon of visibility" formed of luminous bodies moving away from us at speeds very near that the light will be:

$$\frac{2.997925 \times 10^5 \text{ km/s}}{70 \text{ km/s}} 3.26 \times 10^6 \text{ years} = 1.39 \times 10^{10} \text{ years}$$

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The intersection of a 3-dimensional spherical surface of radius R with a 2-dimensional plane which passes through its centre, is a circumference with a radius R_m and a centre at the centre of that surface. Fig. 2 is a representation of such an intersection, in which A represents the position of an observer, B is that of the "horizon of visibility" up to which the said observer can see luminous objects and φ is the angle $\widehat{A\omega B}$.

The length of the arc $\widehat{AB_1}$ is $R_m\varphi$, where R_m is the radius of the visible Universe; i.e. the material Universe to which belong the luminous objets that can be observed from A, and φ is the angle $\widehat{A\omega B_1}$ expressed in radians.

The length of R_m must be smaller than that of R_u, the radius of the Universe, which as a result of the dispersal of zero-point radiation in all directions of space, measures $R_i + ct$; i.e. the initial radius R_i plus as many light years as years have elapsed since $t = 0$. Therefore $R_m\varphi = R_t$, where $\varphi > 1$ and $R_t = R_i + ct$.

On a 2-dimensional spherical surface, the observer at A an only see those luminous objects which are situated on the surface of the spherical zone of height $h = R_m(1 - \cos\varphi)$, whose area, $2\pi R^2(1 - \cos\varphi)$, makes up a fraction $\frac{1 - \cos\varphi}{2}$ of the area of the sphere $4\pi R_m^2$. Keeping in

TABLE I: Values for x, k_λ, $\Delta_x k_s$, R, R_s and R/R_s for some values of $z = k_\lambda/x$. For $z \to \alpha/2\pi = 1.161410 \times 10^{-3}[B]_m \to \infty$; $x \to 0$; $k_\lambda \to 0$. There cannot exist real values of $k_\lambda < 1$, or values of $x < 2\pi/\alpha = 861$. The values of z in lines 6-12 correspond to some of the values of R_0/R_s in Table 3. R_0 is the length of the radius of the Universe at the moment when the last elementary particle was generated from the initial photons.

$z = k_\lambda/x$	x (q_λ)	k_λ (q_λ)	$\Delta_s k_\lambda \left(\frac{q_\lambda}{s}\right)$ [a]	R_0 (l.y.)	R_s (l.y.)	R_0/R_s
1.15×10^{-3}	6.0745×10^{8}	6.9857×10^{5}	1.034×10^{7}	1.606×10^{-9}	1.292×10^{21}	1.243×10^{-30}
10^{-4}	5.299764×10^{13}	5.299764×10^{9}	4.495×10^{6}	1.401×10^{-4}	1.703×10^{17}	8.227×10^{-25}
10^{-5}	4.746727×10^{18}	4.746727×10^{13}	8.990×10^{4}	12.55	1.901×10^{13}	6.602×10^{-13}
10^{-6}	4.691894×10^{23}	4.691894×10^{17}	8.990×10^{3}	1.240×10^{6}	1.923×10^{9}	6.448×10^{-4}
5×10^{-7}	1.500432×10^{25}	7.502160×10^{18}	4.495×10^{3}	3.967×10^{7}	1.203×10^{8}	0.3297
4.42×10^{-7}	2.779216×10^{25}	1.228413×10^{19}	3.971×10^{3}	7.348×10^{7}	7.345×10^{7}	1.0003
4.0098×10^{-7}	4.522692×10^{25}	1.813509×10^{19}	3.605×10^{3}	1.196×10^{8}	4.975×10^{7}	2.404
3.9115×10^{-7}	5.120216×10^{25}	2.002773×10^{19}	3.516×10^{3}	1.354×10^{8}	4.505×10^{7}	3.005
3.7885×10^{-7}	6.007055×10^{25}	2.275773×10^{19}	3.406×10^{3}	1.588×10^{8}	3.965×10^{7}	4.005
3.4218×10^{-7}	9.993193×10^{25}	3.419470×10^{19}	3.076×10^{3}	2.642×10^{8}	2.638×10^{7}	10.015
3.1681×10^{-7}	1.468820×10^{26}	4.653369×10^{19}	2.847×10^{3}	3.882×10^{8}	1.939×10^{7}	20.026
2.9332×10^{-7}	2.158944×10^{26}	6.332615×10^{19}	2.637×10^{3}	5.708×10^{8}	1.425×10^{7}	40.056
2.0×10^{-7}	1.464950×10^{27}	2.929390×10^{20}	2.397×10^{3}	3.873×10^{9}	3.080×10^{6}	1.257
1.75×10^{-7}	2.855570×10^{27}	4.997248×10^{20}	2.098×10^{3}	7.550×10^{9}	1.805×10^{6}	4.183
1.549×10^{-7} [b]	5.257602×10^{27}	8.143376×10^{20}	1.856×10^{3}	1.390×10^{10}	1.108×10^{6}	12.451

[a] $\Delta_s k_\lambda$ is the increase in k_λ per second
[b] Present values

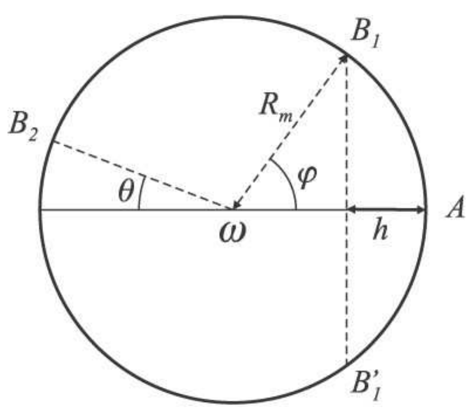

FIG. 2: Fig. 2

mind our deduction of the volume of the 3-dimensional spheric surface as

$$V/2 = 4\pi R^3 \int_0^{\pi/2} \sin^2 \varphi d\varphi = \pi^2 R^3,$$

whence $V = 2\pi^2 R^3$, we can easily find the volume of the zone which corresponds to the angle $\varphi < \pi/2$, through

$$V_z = 4\pi R^3 \int_0^{\varphi} \sin^2 \varphi d\varphi = 2\pi R^3(\varphi - \sin\varphi\cos\varphi),$$

which makes up a fraction

$$\frac{\varphi - \sin\varphi\cos\varphi}{\pi} = \frac{\varphi - (1/2)\sin 2\varphi}{\pi} \quad \text{of } V.$$

The existence of a "horizon of visibility" implies that we have not taken into account those masses which may exist beyond it. The presumed basic uniformity of the Universe allows us to include such masses by multiplying the estimate obtained by considering the observable Universe, by $\frac{\pi}{\varphi - (1/2)\sin 2\varphi}$, the inverse of the previous fraction. This value is 2 for $\varphi = \pi/2$ and 1 for $\varphi = \pi$, when the observer perceives the whole of it.

We must note that for $\varphi > \pi$, the observer at A would double-count the cosmic objects situated at $\pi + \varphi$ and would infer a length of R_m that would be greater than its true length. This possibility would be rejected, were it not the case that images of very distant cosmic objects have been detected which are very much alike, by looking in diametrally opposite directions. It seems important to conduct a program to search for such objects, which may have escaped detection by observers who were looking for other things. Obviously the success of this search would demonstrate that the Universe is configured as a 3-dimensional spherical surface, but any unsuccessful search would not demonstrate the contrary, because there would be no double-count if $\varphi < \pi$.

Table 2 lists possible present values for some characteristics of the Universe which are related to the angle φ. In the second column are shown values for the present speed of increase of the radius of R_m given by $V_m/c = 1/\varphi$. In the third column appear the values for the kinetic energy of an electron moving at a velocity V_m; in the last column are values for the relation between the total mass of the Universe, M_u, and the mass, M_u, perceived by an

TABLE II: Present values for some characteristics related to φ

φ (rad)	$\frac{V_m}{c} = \frac{1}{\varphi}$	$\frac{E_{m_e}}{m_e c^2} = \frac{1}{2\varphi^2}$	$\frac{M_u}{M_\varphi} = \frac{\pi}{\varphi - \frac{1}{2}\sin 2\varphi}$
1.00	1.00	0.500	5.7607
1.20	5/6	0.347	3.634
1.40	0.7143	0.255	2.549
$\pi/2$	0.6366	0.203	2.000
1.75	4/7	0.164	1.632
2.00	1/2	0.125	1.321
2.25	4/9	0.099	1.147
2.45	0.4081	0.083	1.068
2.75	4/11	0.066	1.013
π	0.3183	0.051	1.000

observer whose "horizon of visibility" is that which corresponds to the angle φ, M_φ. However, no mass beyond the "horizon of visibility" from A would attract gravitationally any mass at A.

The effect of increasing the mass of the Universe by the factor M_u/M_φ applies only to the variables R_s and R_0/R_s in Table 1. The estimate of the radius of the Universe R_u has been obtained from its age and is independent of φ. In their turn, the values of R_0 are none other than mere hypotheses of the length of the radius of the Universe at the moment at which there ended the process of formation of matter from the initial photons unconnected with zero-point radiation.

In [5] p. 4, the analysis of the kinetic energy of the last electron generated from the initial photons unconnected with zero-point radiation led us to the following equation

$$\frac{E_t}{m_e c^2} = \frac{1}{2}\left(1 - \frac{R_s}{R_0} + \frac{R_s}{R_0 + R_t}\right); \tag{10}$$

where E_t is the kinetic energy of the said last electron, when the time t has elapsed since $t = 0$, when it was generated; R_0 is the length of the radius of the Universe at $t = 0$, R_s is the length of the Schwarzschild radius, and $R_0 + R_t$ is that of the radius of the Universe at the moment t. This equation derives from our having considered that the electron moved away from ω at a velocity close to that of light, and was subjected only to the gravitational attraction of the rest of the mass of the Universe, which would not significantly differ from $M_0 m_e$.

From (10) we deduce that the condition for the cancelling-out of the energy of that electron is:

$$R_t = \frac{(R_0)^2}{R_s - R_0}; \tag{11}$$

when $R_0 = R_s$ it will cancel out at $R_t \to \infty$, while if $R_0 > R_s$ it can never cancel out.

For the evolution of the velocity of the said electron, we have deduced in [5] pp. 4-5, the equation

$$\frac{dR_m}{dt} = \left(1 - \frac{R_s}{R_0} + \frac{R_s}{R_0 + R_t}\right)^{1/2}, \tag{12}$$

TABLE III: Present values of the rate of increase in the radius of the material Universe, dR_m/dt, of the angle φ, and of the relation M_u/M_φ for some values of R_0/R_s

$\frac{R_0}{R_s}$	φ (rad)	$\frac{dR}{dt}c$	$\frac{M_u}{M_\varphi} = \frac{\pi}{\varphi - \frac{1}{2}\sin 2\varphi}$
< 1	negative	negative	–
1.0044	15.11	0.066	0.2017
1.11274	π	0.3183	1.0000
1.20	2.45	0.408	1.0681
1.333	2.00	0.500	1.3209
1.50	1.73	0.577	1.6653
1.682	$\pi/2$	0.637	2.0000
3.273	1.200	0.833	3.6434
5.00	1.118	0.894	4.3356
10.00	1.0541	0.949	5.0299
20.00	1.0260	0.975	5.3907
628	1.0008	0.9992	5.7487

which implies that for $\frac{R_s}{R_0} \leq 1$ $\frac{dR_m}{dt}$ cannot cancel out, and that when $R_t \to \infty$ the value of $\frac{dR_m}{dt}$ tends towards $\left(1 - \frac{R_s}{R_0}\right)^{1/2}$.

Finally, analysis of the speed at which the horizon of visibility is receding

$$\frac{d\widehat{AB}}{dt} = \varphi\frac{dR_m}{dt} + R_m\frac{d\varphi}{dt},$$

leads us to infer that for $t = 0$, $\varphi = 0$ and for $t \to \infty$, $\varphi \to (1 - R_s/R_0)^{-1/2}$, [5] pp. 8-9. We can definitely say that both the rate at which the radius of the material Universe is now increasing and the present magnitude of the angle φ which defines the "horizon of visibility", are determined by the value of R_s/R_0, that is by the relation between the Schwarzschild radius and the radius of the Universe at the moment $t = t_0$ when the last electron was generated from the initial photons unconnected to zero-point radiation. Table 3 shows the present values of the angle φ, the rate of increase in the radius of the material Universe, dR_m/dt, and the relation between the mass of the Universe, M_u and that of the visible Universe M_φ. These values are given for the values of R_0/R_s falling between 1.000 and 628 which appear in Table 1, and for values which in Table 2 are equal to π radians, 2.45 radians, 2 radians, $\pi/2$ radians and 1 radian. This completes a fair panorama of the effects of the possible values of R_0/R_s on important characteristics of the Universe.

- For $R_0/R_s = 1$, $\varphi \to \infty$, $dR/dt \to 0$: This value of φ is inadmissible, as we would be contemplating an infinite series of images of he same cosmic objects.
- For $R_s/R_0 < 1$, we would obtain negative values for dR/dt. This does not seem possible for $t = 1.39 \times 10^{10}$ years.

IV. ANALYSIS OF THE POSSIBILITY OF THE BIG CRUNCH AND EVALUATION OF THE RADIUS OF THE MATERIAL UNIVERSE

Equation (10) in [5], which expresses the evolution of R_m as a function of t, and equation (14) in [5], which expresses the evolution of φ as a function of t, include the expression $(1-R_s/R_0)^{1/2}$, which gives a complex number for $R_s/R_0 > 1$; which may mean that it is impossible for R_0 to be smaller than R_s.

If we abstract from these equations which derive from equation (5) in [5], and consider only this equation (5), we obtain:

$$\frac{dR_m}{dt} = \left(1 - \frac{R_s}{R_0} + \frac{R_s}{R_0 + t}\right)^{1/2} = \left(1 - \frac{R_s}{R_0} + \frac{R_s}{R_m}\right)^{1/2},$$

where R_m is the present length of the radius of the material Universe. If we substitute $\frac{R_s}{R_0}$ for $(1+x)$, we obtain $\frac{dR_m}{dt} = \left(\frac{R_s}{R_m} - x\right)^{1/2}$, which will be real for $R_s/R_m > x$.

The redshift in the light which comes from the very distant galaxies allows us to know that the radius of the material Universe, R_m, is increasing, that is, that $dR_m/dt > 0$, which means that $R_m > R_s$. Therefore $x < 1$.

We can see from Table 3 that for $R_0/R_s < 1.11274$ the angle φ measures more than π radians, which determines that $M_u/M_\varphi < 1$. Therefore $M_u < M_0$.

Table 3 shows that for $R_s/R_0 \to 1$, $\varphi \to \infty$, $\frac{dR_m}{dt} \to 0$, and $\frac{M_u}{M_\varphi} \to 0$. This means that the suggested values $\frac{R_s}{R_0} = 1 + x$, $x < 1$ are incompatible with the hypothesis which is analysed in this paper. In other words this hypothesis is incompatible with the "Big Crunch".

* * *

Equation (12) can be written as $\frac{dR_m}{\left(1 - \frac{R_s}{R_0} + \frac{R_s}{R_m}\right)^{1/2}} = dt$.

If we integrate between $t = 0$, for which value $R_m = R_0$, and t, whose value governs R_m, equation (12) becomes:

$$\int_{R_0}^{R_t} \frac{dR_m}{\left(1 - \frac{R_s}{R_0} + \frac{R_s}{R_m}\right)^{1/2}} = t$$

To solve this integration we substitute $R_m = \frac{R_s}{y}$, $dR_m = -\frac{R_s dy}{y^2}$. Also, we simplify by $1 - \frac{R_s}{R_0} = a$, so that we have:

$$-R_s \int_{R_0}^{R_s/R_m} \frac{dy}{y^2(1+ay)^{1/2}} = R_s \left[\frac{(a+y)^{1/2}}{ay}\right]_{R_s/R_0}^{R_s/R_m} +$$

$$+\frac{R_s}{2a\sqrt{a}} \log \left[\frac{(a+1)^{1/2} - a^{1/2}}{(a+y)^{1/2} + a^{1/2}}\right]_{R_s/R_0}^{R_s/R_m},$$

so that if $(1 - R_s/R_0 + R_s/R_m) = (a + R_s/R_m) = b$; we finally arrive at:

$$R_m = t\left(\frac{a}{b}\right)^{1/2} + \frac{R_0}{b^{1/2}} + \frac{R_s b^{1/2}}{2a} \log\left[\frac{b^{1/2} - a^{1/2}}{1 - a^{1/2}} \frac{1 + a^{1/2}}{b^{1/2} + a^{1/2}}\right] \tag{13}$$

Since $b = 1 - R_s/R_0 + R_s/R_m$, equation (13) is extremely complex and to find the value of R_m we have to resort to successive iterations starting from $R_m = \left(1 - \frac{R_s}{R_0}\right)^{1/2} t$, where $\left(1 - \frac{R_s}{R_0}\right)^{1/2}$ is an estimate for the present value of $\frac{dR_m}{dt}$, which leads to a value for R_m which is smaller than that given by equation (13).

Table 2 shows the values towards which $v_m = dR_m/dt$ will tend for $t \to \infty$, $R_m \to \infty$. Obviously, the present shorter estimate of the length of R_m must correspond to the lower of these values, $v_m = 0.3183c$, which is the value given for $\varphi = \pi$. For this value the visible mass M_φ would be exactly equal to M_u, that is the visible mass of the Universe.

If we introduce into (13) the value $R_m = 0.3183c \times 1.39 \times 10^{10}$ years $= 4.42437 \times 10^9$ light-years, evidently smaller than the present value of R_m, after 10 interactions we arrive at $R_m = 9.92345 \times 10^9$ light-years. Therefore 9.923×10^9 light-years $< R_m < 1.39 \times 10^{10}$ light-years (14).

Within this interval fall all the possible values of the length of the radius of the material Universe, R_m, which correspond to the values of v_m in Table 2 that fall between $v_m = c$, for $\varphi = 1$ radian, and $v_m = 0.3183c$, for $\varphi = \pi$ radians.

* * *

Equation (8) allows us to suggest that the total energy inherent to the curvature of the Universe can be given by:

$$E^*_{cu} = \frac{2\pi^2 hc}{q_\lambda} k_u^3 \left\{\frac{1}{2x} + \frac{1}{3x^2} - \frac{1}{6x^4} + \cdots\right\},$$

where k is a constant. The wavelength, x, of the most energetic photons in zero-point radiation is proportional to the length of the radius of the Universe, R_u, and the values of x in Table 1, $x > 6.07 \times 10^8$, imply that the

value of the sum $\dfrac{1}{3x^2} - \dfrac{1}{6x^4} + \cdots$ is insignificant when compared to $1/2x$, and we can write:

$$E^*_{cu} = \frac{\pi^2 hck^3}{xq_\lambda},$$

which states that the total energy inherent to the curvature of the space is inversely proportional to x; i.e. inversely proportional to the radius of the Universe and, therefore, directly proportional to the curvature of the Universe.

Within a space configured as a 3-dimensional spherical surface, all points are affected by its curvature, and from equation (7) we can obtain

$$\frac{E_{cu}}{(q_\lambda)^3} = \frac{E_{0x}}{(q_\lambda)^3} - \frac{hc}{(q_\lambda)^4}\frac{1}{3x^3}$$

$$= \frac{hc}{(q_\lambda)^4}\left\{\frac{1}{2x^4} + \frac{1}{3x^5} - \frac{1}{6x^7} + \cdots\right\}$$

which, given the magnitude of the possible values of x, can be simplified to

$$\frac{E_{cu}}{(q_\lambda)^3} = \frac{hc}{(q_\lambda)^4}\frac{1}{2x^4}; \qquad \text{whence}$$

$$\frac{E_{cu}}{(l_e)^3} = \frac{\pi}{\alpha}\frac{(k_\lambda)^4}{x^4} m_e c^2,$$

which expresses the energy per $(l_e)^3$ inherent to the curvature of the Universe. This equation may be written:

$$\frac{E_{cu}}{(l_e)^3} = \frac{\pi}{\alpha}(z)^4 \frac{m_e c^2}{(l_e)^3}; \qquad \text{where} \;\; z = \left(\frac{k_\lambda}{x}\right)^4. \tag{15}$$

The increase in the radius of the Universe presupposes a proportional increase in x, which is equivalent to $1.126651 \times 10^{-13} q_\lambda/t_e$, and causes a decrease in E_{cu}. This decrease produces a certain flow of energy per unit of volume, which translates into an expansive force. In other words, the curvature of the Universe gives up energy as it stretches, which can be understood better with the help of the image of an arrow impelled by the energy yielded by the distending bow as it is released.

Equation (9) can be written in the form:

$$z^4 = \frac{3\alpha}{4\pi^3 x[B]_m},$$

whence

$$\frac{\partial(z^4)}{\partial x}dx = \frac{3\alpha}{4\pi^3[B]_m}\frac{dx}{x^2}.$$

Therefore:

$$\frac{\Delta E_{cu}}{(l_e)^3} m_e c^2 = \frac{-3}{4\pi^2[B]_m}\frac{\Delta x}{x^2}\frac{m_e c^2}{(l_e)^3} \tag{16}$$

Within space configured as a 3-dimensional spherical surface, the volume of the electron is $2\pi^2 l_e^3$. Therefore the stretching of the curvature of space implies, for the electron, a centrifugal force given by

$$f_{ce} = 2\pi^2\left(\frac{-3}{4\pi^2[B]_m}\frac{\Delta x}{x^2}\right) m_e l_e t_e^{-2}.$$

The value of Δx expressed in l_e per t_e is $\Delta x = 1.383518 \times 10^{-34} l_e/t_e$. According to our hypothesis this value does not change. Therefore we can write

$$f_{ce} = -\frac{2.075277 \times 10^{-34}}{[B]_m x^2} m_e l_e t_e^{-2}. \tag{17}$$

For the present values $x = 6.456292 \times 10^6 l_e$, $[B]_m = 1.944468 \times 10^{-5}$, we obtain $f_{ce} = -2.560407 \times 10^{-43} m_e l_e t_e^{-2}$. Against this centrifugal force, the attraction determined by the mass of the Universe is:

$$f_g = \frac{m_x \times 1.55 \times 10^{79} m_x}{(R_{ux})^2 (l_x)^2}\frac{(q_\lambda)^2 c^2}{2\pi *} = \frac{1.55 \times 10^{79} (m_x)^2 c^2}{2\pi (R_{ux})^2 (k_{\lambda x})^2 m_e l_e},$$

where R_{ux} and $k_{\lambda x}$ are, respectively, the length of the radius of the Universe expressed in l_x and the length of the radius of the electron expressed in q_λ, at t_x.

The relations $l_x = k_{\lambda x} q_\lambda$; $l_e = k_\lambda q_\lambda$; $m_e l_e = m_x l_x$ allow us to write $m_x = m_e k_\lambda / k_{\lambda x}$. By introducing this in f_g, we obtain:

$$f_g = \frac{1.55 \times 10^{79} (k_\lambda)^2}{2\pi (R_{ux})^2 (k_{\lambda x})^4} m_e l_e t_e^{-2} = \frac{1.027876 \times 10^{121}}{2\pi (R_{ux})^2 (k_{\lambda x})^4} m_e l_e t_e^{-2}. \tag{18}$$

For the present values $R_u = 4.666577 \times 10^{40} l_e$; $k_{\lambda x} = k_\lambda = 8.143 \times 10^{20}$ we obtain $f_g = 1.708229 \times 10^{-45} m_e l_e t_e^{-2}$, which is equal to $6.67 \times 10^{-3} f_{ce}$. For the lower limit of R_u, 9.92×10^9 l.y. instead of 1.39×10^{10} l.y., $f_g = 3.354 \times 10^{-44} m_e l_e t_e^{-2}$, also very inferior to f_{ce}.

From (17) and (18), we obtain:

$$\frac{f_{ce}}{f_g} = \frac{2.075277 \times 10^{-34}/[B]_m x^2}{1.027876 \times 10^{121}/2\pi (R_{ux})^2 (k_{\lambda x})^4}$$

$$= \frac{1.267482 \times 10^{-154} (R_{ux}/x)^2 (k_{\lambda x})^4}{[B]_m}$$

According to our hypothesis R_{ux}/x is constant and its value is 7.227951×10^{33}. Therefore:

$$\frac{f_{ce}}{f_g} = \frac{6.621742 \times 10^{-87} [k_{\lambda x}]^4}{[B]_m} \tag{19}$$

For the present values $k_{\lambda x} = k_\lambda = 8.143375 \times 10^{20}$; $[B]_m = 1.944468 \times 10^{-5}$, we obtain $f_{ce}/f_g = 149.758$, whence $f_g/f_{ce} = 6.67 \times 10^{-3}$ as before.

$[B]_m$ decreases over time. For $t_x = 12.55$ years after the Big Bang, $[B]_m = 1.239543 \times 10^{-3}$, and at present, $t_x = 1.39 \times 10^{10}$ years, $[B]_m = 1.944468 \times 10^{-5}$. In Table 1 we can see that $k_{\lambda x}$ increases over time and, therefore,

the value of f_{ce}/f_g also increases. For $t_x = 12.55$ years after the Big Bang, it was equal to 9.05×10^{-30} instead of 149.78.

When $f_{ce} = f_g$, i.e. when the centrifugal force which comes from the decrease in the curvature of the Universe are equal to the gravitational attraction of the whole mass of the Universe, we have:

$$\frac{6.621742 \times 10^{-87}[k_{\lambda x}]^4}{[B]_m} = 1,$$

which happens at $t_x = 4.36 \times 10^9$ y.; $k_\lambda = 3.234 \times 10^{20}$; $[B]_m = 7.249 \times 10^{-5}$; $x = 1.650 \times 10^{27}$.

We know that R_m is increasing and that the centrifugal forces inherent to the decrease in the Universe's curvature prevail over the gravitational attraction and will always prevail over it; therefore the hypothesis which is proposed in this paper excludes the Big Crunch.

The introduction of the centrifugal force inherent to the stretching of the curvature of space was made through the addition of the term $\dfrac{1}{2x^4}$ which appears in the parenthesis of equation (7). The fact of not including it in equation (3) implies relative errors inferior to $\dfrac{3}{2}\dfrac{1}{x}$, which are insignificant for the values of x in Table 1. Therefore it is unnecessary to change anything in that Table.

V. REFLECTIONS OF THE CONSTANT α AND ON THE GENERATION OF ELEMENTARY PARTICLES

In the (e, m_e, c) system of units the equation which gives the energy of the photons of wavelength λl_e is:

$$E_\lambda = \frac{hc}{\lambda l_e} = \frac{2\pi}{\alpha}\frac{1}{\lambda}m_e c^2. \tag{20}$$

For $\lambda = \dfrac{2\pi}{\alpha} l_e$ we obtain $E_\lambda = m_e c^2$, which is the energy equivalent of the mass of the electron whose radius, r_e, measures l_e. The wavelength $2\pi/\alpha$ is equal to the length of a circumference of radius $R_e = l_e/\alpha = r_e/\alpha$, which implies a relationship of the scale $1/\alpha$ between the wavelength $(2\pi/\alpha)l_e$ and the length of the circumference of radius r_e. In all cases, an elementary particle of mass m_x has a radius $r_x = \dfrac{m_e}{m_x} l_e$ and the photons of wavelength $\dfrac{2\pi}{\alpha} r_x$ have an energy

$$E_x = \frac{2\pi}{\alpha}\frac{m_e c^2}{(2\pi/\alpha)(m_e/m_x)} = m_x c^2,$$

which is the energy equivalent to the mass m_x. The wavelength $\lambda_x = \dfrac{2\pi}{\alpha} r_x$ is equal to the length of a circumference of radius r_x/α.

The product $m_e l_e = e^2/c^2$ is a quantic threshold. There are no charges smaller than "e", or speeds greater than "c". On the other hand the relationship $r_x m_x = r_e m_e$ is the requisite condition for the spin of a particle of mass m_x and radius r_x to be equal to $\hbar/2$, so that a photon of wavelength λ_x has an energy of $E_x = (m_e/\lambda_x)c^2 = m_x c^2$, equal to the energy equivalent of the mass of the particle, while the relationship between the wavelength of the photon with energy E_x and the length of the circumference whose radius is that of the elementary particle of mass E_x/c^2, is always equal to $1/\alpha$.

The value of the constant α is not affected by hypothetical changes in the wavelength "x" of the photons of greatest energy in zero-point radiation. However any change in "x" would produce a change in the length of the radius of the electron $r_e = k_\lambda q_\lambda$, which is determined by the fact that, at this distance from its centre, the centrifugal force of the repulsion of its charge against itself is equal to the centripetal force inherent to the interaction of the particle with zero-point radiation. This change in the length of its radius produces an inversely proportional change in the mass of the electron, because $m_x r_x$ must continue to be equal to $m_e r_e$. Therefore the wavelength of a photon whose energy is equal to $m_x c^2$ will also change in proportion to the change in length in the electron's radius, so that the relationship between the new wavelength and the new radius continues to be $1/\alpha$.

The expression of the equivalence between those centrifugal and centripetal forces relates k_λ and x through equation (9), which is an expression of equation (17) of [4] and can be written:

$$x = \frac{3\alpha/4\pi^3}{z^4[B]_m},$$

where

$$z = \frac{k_\lambda}{x}$$

$$[B]_m = \sum_1^\infty \left(\frac{2\pi z}{\alpha}\right)^m$$

$$T_m = (-1)^{m+1}$$

$$\left\{\frac{1}{m+1} + \frac{2}{m+2} - \frac{3}{m+3} - 1 - \frac{m(m-1)}{6}\right\}\frac{1}{m+3}.$$

The series $[B]_m$ has a positive and finite value for $z < \dfrac{\alpha}{2\pi}$ and has no value for $z \geq \dfrac{\alpha}{2\pi}$. On the other hand $\dfrac{k_{\lambda t}}{x_t} = z_t < \dfrac{\alpha}{2\pi}$; where $x_t q_\lambda$ is the wavelength of the most energetic photons in zero-point radiation t years after the Big Bang and $k_{\lambda t} q_\lambda$ is the radius of the electron at that time.

Because of the quantic threshold $m_x r_x = e^2/c^2$; $m_t k_{\lambda t} = m_e l_e$, whence $m_t = \dfrac{m_e l_e}{k_{\lambda t}}$, and the wavelength

of the photon with energy $m_t c^2$, expressed in (q_λ), is

$$\lambda = \frac{2\pi}{\alpha} k_{\lambda t}$$

whilst the wavelength of the most energetic photons in zero-point radiation is

$$x_t > \frac{2\pi}{\alpha} k_{\lambda t},$$

so that there could never occur the generation of electrons or any other elementary particle. The value of the product $\frac{2\pi}{\alpha} z$ increases as x decreases and tends toward 1 as x tends towards 0. For the present value of x, the value of z is 1.548876×10^{-7}, and, for $z = 1.150 \times 10^{-3} = 0.99(\alpha/2\pi)$, $x = 6.0745 \times 10^8$, which corresponds to $t = 1.606 \times 10^{-9}$ years after $t = 0$, very approximately $0.05s$ after the Big Bang, and exposes the extremely rapid variation of x between the said value and $z = \alpha/2\pi$.

Some cosmologists suppose that the present laws of Physics did not apply during the time immediately after the Big Bang and that the generation of the elementary particles happened on a short period of time. Nevertheless it is better to suppose that zero-point radiation cannot generate elementary particles and that the primeval space which emerged with the Big Bang contained other photons able to generate those particles which are now in our Universe.

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